植 物 分 类 学 报　39(5):405~422(2001)
Acta Phytotaxonomica Sinica

国产毛茛属11种及其4个近缘属5种植物的细胞学研究

杨亲二
（中国科学院植物研究所系统与进化植物学开放研究实验室　北京 100093）

Cytology of eleven species in the genus *Ranunculus* L. and five in its four related genera from China

YANG Qin-Er
(*Laboratory of Systematic and Evolutionary Botany, the Chinese Academy of Sciences*, Beijing 100093)

Abstract The somatic chromosome number and detailed chromosome morphology have been studied in eleven species of *Ranunculus* and five species of its four related genera, all from China, namely *Callianthemum pimpinelloides* (D. Don) Hook. f. et Thoms. (2n = 4x = 32), *Adonis brevistyla* Franch. (2n = 2x = 16), *Ranunculus potaninii* Kom. (2n = 4x = 32), *R. popovii* var. *stracheyanus* (Maxim.) W. T. Wang (2n = 4x = 32), *R. tanguticus* (Maxim.) Ovcz. (2n = 4x = 32), *R. nematolobus* Hand.-Mazz. (2n = 2x = 16), *R. sceleratus* L. (2n = 4x = 32), *R. ficariifolius* Lévl. et Vant. (2n = 4x = 32), *R. japonicus* Thunb. (2n = 2x = 14), *R. laetus* Wall. (2n = 2x = 14), *R. trigonus* Hand.-Mazz. (2n = 2x = 16), *R. sinovaginatus* W. T. Wang (2n = 4x = 32), *R. chinensis* Bunge (2n = 2x = 16), *Halerpestes tricuspis* (Maxim.) Hand.-Mazz. (2n = 4x = 32), *H. sarmentosa* (Adams) Kom. (2n = 4x = 32) and *Batrachium bungei* (Steud.) L. Liou (2n = 2x = 16; 2n = 3x = 24). From the chromosomal data relationships of the five genera and of some species within *Ranunculus* are discussed.

Key words Ranunculaceae; *Callianthemum* C. A. Meyer; *Adonis* L.; *Ranunculus* L.; *Halerpestes* E. Greene; *Batrachium* S. F. Gray; Chromosome number; Karyotype

1 Introduction

Ranunculus L. (Ranunculaceae) is a large genus of about 600 species from both hemispheres (Tamura, 1995). In China, 122 species have been recorded in this genus (Yang, 2000; Liao & Xu, 1997; Wang, 1995a, 1995b).

Cytological studies in *Ranunculus* have been reported in various countries (e.g. Diosdado & Pastor, 1993; D'Ovidio & Marchi, 1990; Kapoor, 1981; Goepfert, 1974; Kapoor & Löve, 1970; Kurita, 1957, 1955; Coonen, 1939). The Chinese species of *Ranunculus*, however, are cytologically poorly known. Only 19 species from China have had reports of chromosome numbers (Yang, 2000; Liao & Xu, 1997; Liao *et al.*, 1996; Sha *et al.*, 1995; Yang *et al.*, 1994; Fujishima, 1991; Liao & Chen, 1991; Liao *et al.*, 1991), of which 14 have had reports of chromosome morphology.

This paper is to report the chromosome number and morphology of 11 species in *Ranunculus* and five in its four more or less related genera, including *Callianthemum*, *Adonis*, *Halerpestes* and

---

Received 16 December 2000, accepted 3 January 2001.
Supported by a Key Project Grant from the Chinese Academy of Sciences(National Resources and Environment).

Batrachium. This is envisaged as a pilot study of the cytology of the Chinese species of *Ranunculus* and its related genera upon which further investigations involving more species can be based.

2 Material and Methods

All the plants studied were collected in the field from Yunnan, Sichuan and Qinghai of China (Table 1). They were cultivated in pots in the experimental garden of Kunming Institute of Botany, the Chinese Academy of Sciences, before their root tips were harvested for the cytological study, but with the aquatic *Batrachium bungei* being an exception, in which the roots were directly collected in the wild, as this plant was not successfully transplanted to Kunming. Actively growing root tips were pretreated in 0.1% colchicine at about 20℃ for three hr before they were fixed in Carnoy Ⅰ (glacial acetic acid: absolute ethanol = 1:3) at 4℃ for 30 min, then they were macerated in 1:1 mixture of 1 mol/L hydrochloric acid and 45% acetic acid at 60℃ for two min, and stained and squashed in 1% aceto-orcein.

Karyotype formulas were based on the data of measurements of mitotic metaphase chromosomes. The symbols used to describe the karyotypes followed Levan *et al*. (1964). The karyotype classification followed Stebbins (1971).

Table 1 Chromosome counts and source of material studied

Taxon	Provenance	Voucher	2n
Callianthemum pimpinelloides	Huadianba, Cangshan Mt., Dali, Yunnan Zhongdian, Yunnan	Q. E. Yang 94-14 X. Gong 92-47	32 32
Adonis brevistyla	Heibaishui, Yulongshan Mt., Lijiang, Yunnan Xiaozhongdian, Zhongdian, Yunnan	Q. E. Yang 94-130 Q. E. Yang & H. Z. Kong 98-136	16 16
Ranunculus potaninii	Bitahai, Zhongdian, Yunnan	X. Gong 92-60	32
R. popovii var. *stracheyanus*	Yakou, Datong, Qinghai	Q. E. Yang 95-34	32
R. tanguticus	Zhegushan Mt., Lixian, Sichuan	Y. B. Luo 64	32
R. nematolobus	Xiaohuadianba, Cangshan Mt., Dali, Yunnan	Q. E. Yang 94-05	16
R. sceleratus	Xiaocaiyuan, Kunming, Yunnan	Q. E. Yang 94-57	32
R. ficariifolius	Huadianba, Cangshan Mt., Dali, Yunnan Kena, Weixi, Yunnan	Q. E. Yang 94-29 Q. E. Yang & H. Z. Kong 98-203	32 32
R. japonicus	Yaan, Sichuan Baizhuang, Xunhua, Qinghai	Q. E. Yang 93-01 Q. E. Yang 95-12	14 14
R. laetus	Huadianba, Cangshan Mt., Dali, Yunnan	Q. E. Yang 94-17	14
R. trigonus	Yulongshan Mt., Lijiang, Yunnan	Q. E. Yang 94-140	16
R. sinovaginatus	Baimangshan Mt., Deqen, Yunnan Yulongshan Mt., Lijiang, Yunnan Napahai, Zhongdian, Yunnan	Q. E. Yang 94-82 X. Gong 92-19 X. Gong 92-31	32 32 32
R. chinensis	Heilongtan, Kunming, Yunnan	Q. E. Yang 94-62	16
Halerpestes tricuspis	Guashizhe, Tongren, Qinghai	Q. E. Yang 95-18	32
H. sarmentosa	Zhongdian, Yunnan	Q. E. Yang & H. Z. Kong 98-242	32
Batrachium bungei	Zhongdian, Yunnan	Q. E. Yang & H. Z. Kong 98-600	16,24

The voucher specimens were deposited in the Herbarium of Institute of Botany, the Chinese Academy of Sciences (PE). The taxonomic treatment of the genus *Ranunculus* followed Wang (1995a, 1995b) and of the genus *Halerpestes* followed Wang (1995c, 1986).

3 Results

3.1 **Callianthemum** C. A. Meyer

3.1.1 **C. pimpinelloides** (D. Don) Hook. f. et Thoms.

This species is distributed in SW China's Sichuan, Yunnan, Xizang (Tibet) and NW China's Qinghai, as well as in Nepal, Sikkim and N India, growing in alpine meadows at altitudes of over 3200 m. Two populations in NW Yunnan, one from Dali and the other from Zhongdian, were examined. Both populations were found to be tetraploids with the chromosome number of $2n = 4x = 32$ (Figs. 1 ~ 3), a new count for this species. Yang and Wu (1993), and Vir Jee and Kachroo (1985) reported the number of $2n = 16$ for this species from the Hohxil Region of NW China's Qinghai and the Kashimir Himalaya respectively.

The karyotypes of the two populations examined were essentially uniform, consisting of 24 median-centromeric (m) and 8 subterminal-centromeric (st) chromosomes ($2n = 4x = 24m + 8st$) (Figs. 2, 3) and belonging to Stebbins' 2B type. The chromosomes ranged from 5.4 ~ 2.1 μm in length, their mean length being 3.9 μm. Yang and Wu (1993) reported the diploid karyotype as consisting of 6 median-centromeric and 10 submedian-centromeric (sm) chromosomes, showing that the tetraploid karyotype was not a simple doubling of the diploid one. Kurita (1958b) reported the chromosome number of $2n = 32$ and a very similar karyotype for *C. insigne* from Japan but $2n = 16$ and a karyotype consisting of 12 m and 4 sm chromosomes for *C. hondoense*, also from Japan.

3.2 **Adonis** L.

3.2.1 **A. brevistyla** Franch.

This species is distributed in China's Xizang, Yunnan, Sichuan, Gansu, Shaanxi and Shanxi, as well as in Bhutan. Two populations in NW Yunnan, one from Lijiang and the other from Zhongdian, were examined. Both populations were found to be diploids with the chromosome number of $2n = 2x = 16$ (Figs. 4 ~ 7). Their karyotypes were very similar, consisting of 8 median-centromeric, 2 submedian-centromeric and 6 subterminal-centromeric chromosomes (Figs. 6, 7) and belonging to Stebbins's 2A type. It should be noted that the arm ratio of the 6 subterminal-centromeric chromosomes (ranging from 3.1 ~ 3.2) is only a little higher than the critical value of the arm ratio (3.0) between the submedian-centromeric and subterminal-centromeric chromosomes. In the fourth chromosome pair satellites were observed on the short arms. The karyotype was formulated as $2n = 2x = 8m + 2sm + 6st(2sat)$. The chromosomes ranged from 10.8 ~ 7.9 μm in length, their mean length being 9.3 μm. Yang and Wu (1993) reported the karyotype of *A. coerulea* Maxim. as consisting of 6 m and 10 sm chromosomes, in which no satellite was observed. Suda and Herai (1991) found that *A. amurensis* Regel et Radde always has two chromosome pairs (the fifth and the sixth) with satellites on the short arms. The chromosomes of *A. brevistyla* is worthy of a re-examination to determine if satellited chromosomes are really absent in this species, as such chromosomes may be used as cytological marker of the genus *Adonis*.

3.3 **Ranunculus** L.

Subgen. **Ranunculus** sect. **Auricomus** (Spach) Schur

In Wang's classification of the Chinese *Ranunculus* (Wang, 1995a, 1995b), sect. *Auricomus*

(Spach) Schur includes 12 series. The following four species all belong to ser. *Tangutici* Ovcz.

3.3.1 **R. potaninii** Kom.

This species is distributed in China's SW Gansu, S Sichuan, NW Yunnan and SE Xizang as well as in Nepal. One population from Yunnan was examined and found to be tetraploid with the chromosome number of $2n = 4x = 32$ (Figs. 8, 14). The chromosomes ranged from 5.5 ~ 3.6 μm in length, their mean length being 4.4 μm. The karyotype consisted of 10 median-centromeric, 6 submedian-centromeric, 12 subterminal-centromeric and 4 terminal-centromeric (t) chromosomes (Fig. 14) and belonged to Stebbins' 3A type. The karyotype was formulated as $2n = 4x = 10m + 6sm + 12st + 4t$.

3.3.2 **R. popovii** var. **stracheyanus** (Maxim.) W. T. Wang

This variety is distributed in N and NW China as well as in Nepal and NW India. One population from Qinghai was examined and found to be tetraploid with the chromosome number of $2n = 4x = 32$ (Figs. 9, 15). The chromosomes were quite small and ranged from 3.5 ~ 1.6 μm in length, their mean length being 2.4 μm. The karyotype consisted of 24 median-centromeric and 8 submedian-centromeric chromosomes (Fig. 15) and belonged to Stebbins' 2B type. The karyotype was formulated as $2n = 4x = 24m + 8sm$. Kurosawa (1971) reported the number of $2n = 48$ for this variety from the Singalila Range of the eastern Himalaya under the name *R. pulchellus* C. A. Meyer var. *stracheyanus* (Maxim.) Hand.-Mazz.

3.3.3 **R. tanguticus** (Maxim.) Ovcz.

This species is widely distributed in SW and N China, as well as in Nepal and N India, growing in alpine meadows. One population from Sichuan was examined and found to be tetraploid with the chromosome number of $2n = 4x = 32$ (Figs. 10, 16). The chromosomes were quite small and ranged from 3.3 ~ 1.3 μm in length, their mean length being 2.3 μm. The karyotype consisted of 24 median-centromeric and 8 submedian-centromeric chromosomes (Fig. 16) and belonged to Stebbins' 2B type. The karyotype was formulated as $2n = 4x = 24m + 8sm$. I have also examined the chromosomes of this species from S Qinghai and NW Yunnan and found the number to be also $2n = 32$, but the preparations are not good enough to allow making a karyotype analysis so the results are not given here.

3.3.4 **R. nematolobus** Hand.-Mazz.

This species is endemic to Yunnan, growing in alpine meadows. One population was examined and found to be diploid with the chromosome number of $2n = 2x = 16$ (Figs. 11, 17). The chromosomes ranged from 4.6 ~ 2.9 μm in length, their mean length being 3.9 μm. The karyotype consisted of 6 median-centromeric and 10 submedian-centromeric chromosomes (Fig. 17) and belonged to Stebbins' 3A type. The karyotype was formulated as $2n = 2x = 6m + 10sm$.

Sect. **Hecatonia** (Lour.) DC.

This monotypic section includes only the following one species.

3.3.5 **R. sceleratus** L.

This species is very widely distributed in the world. One population from Yunnan was examined and found to be tetraploid with the chromosome number of $2n = 4x = 32$ (Figs. 12, 18), confirming the previous reports for materials from Korea (Fujishima, 1996), Japan (Fujishima, 1990; Kurita, 1960), China (Liao *et al*., 1991), Canada (Kapoor, 1981; Goepfert, 1974), Europe (Goepfert, 1974) and the United States of America (Coonen, 1939). The karyotype consisted of 20 median-centromeric and 12 submedian-centromeric chromosomes (Fig. 18), and belonged to Stebbins' 2B type. The karyotype was formulated as $2n = 4x = 20m + 12sm$. The chromosomes ranged from 4.0 ~ 1.7 μm in length, their mean length being 2.9 μm. Kapoor (1981) found that prominent secondary constrictions are present on the short arms of the first and fifth chromosome pairs in the karyotype while Fujishima (1996, 1990) found that the 15th chromosome pair has satellites on the short arms, but in this study neither satellited nor secondarily constricted chromosomes were observed. Liao *et al*. (1991) did not also observe such chromosomes in material from Jiangxi, China. Goepfert (1974) noted that this species has the smallest chromosomes in the genus *Ranunculus*. From the present results its chromosomes are slightly larger than those of *R. tanguticus* and of *R. popovii* var. *stracheyanus* as well.

Sect. **Ficariifolium** L. Liou

This section includes two species. The following one species is here studied.

3.3.6 R. ficariifolius Lévl. et Vant.

This species is distributed in China's Yunnan, Guizhou, Sichuan, Hubei, Hunan and Jiangxi as well as in Bhutan, Sikkim, Nepal and N India. Two populations in NW Yunnan, one from Dali and the other from Weixi, were examined and found to be tetraploids with the chromosome number of $2n = 4x = 32$ (Figs. 13, 19, 20). The chromosomes ranged from 5.3 ~ 1.8 μm in length, their mean length being 3.1 μm. Their karyotypes were very similar, consisting of 16 median-centromeric and 16 submedian-centromeric chromosomes (Figs. 19, 20) and belonging to Stebbins' 2B type. The karyotype was formulated as $2n = 4x = 16m + 16sm$.

Sect. **Ranunculus**

This section includes 3 series. Three species in ser. *Ranunculus* and two species in ser. *Repentes* W. T. Wang are here studied.

Ser. **Ranunculus**

3.3.7 R. japonicus Thunb.

This species is one of the commonest *Ranunculus* species in China. It is also distributed in Korea, Japan and Siberia of Russia. Two populations, one from Sichuan and the other from Qinghai, were examined and found to be diploids based on $x = 7 (2n = 2x = 14)$ (Figs. 21, 22, 27, 28). The chromosomes ranged from 7.4 ~ 4.0 μm in length, their mean length being 5.1 μm. Their karyotypes were very similar, consisting of 6 median-centromeric, 4 submedian-centromeric and 4 subterminal-centromeric chromosomes ($2n = 2x = 6m + 4sm + 4st$) (Figs. 27, 28) and belonging to Stebbins' 3A type, but in the population from Qinghai, a satellite was observed on the short arm of the 14th chromosome (Fig. 28). This species has been extensively studied cytologically (Yang *et al*., 1994; Liao & Chen, 1991; Fujishima, 1986; Kurita 1957, 1955; Hara & Kurosawa, 1956). Its chromosome number of $2n = 14$ is usually constant, but up to 11 B chromosomes have been found in some populations and the B chromosome number is variable between and within the populations, even among the roots of the same plant individual (Fujishima, 1986). The chromosome morphology is generally also stable, but the satellites, which are always attached to the short arms of the sixth chromosome pair, are of some variation in size between and within populations (Fujishima, 1986).

3.3.8 R. laetus Wall

This species is distributed in China's Yunnan and Xizang as well as in India. One population from Yunnan was examined and found to be diploid based on $x = 7$ ($2n = 2x = 14$) (Figs. 23, 29). The chromosomes ranged from 7.0 ~ 3.6 μm in length, their mean length being 4.8 μm. The karyotype of this species is very similar to that of its close relative, *R. japonicus*, consisting of 6 median-centromeric, 4 submedian-centromeric and 4 subterminal-centromeric chromosomes (Fig. 29) and belonging to Stebbins' 3A type. The karyotype was formulated as 2n = 2x = 6m + 4sm + 4st. No satellited chromosome was observed. It is noteworthy that Roy and Sharma (1971) reported the number of 2n = 4x = 28 for this species from India.

3.3.9 **R. trigonus** Hand.-Mazz.

This species is distributed in Sichuan and Yunnan. One population from Yunnan was examined and found to be diploid with the chromosome number of 2n = 2x = 16 (Figs. 24, 30). The chromosomes ranged from 5.0 ~ 4.0 μm in length, their mean length being 4.6 μm. The karyotype consisted of 6 median-centromeric, 6 submedian-centromeric and 4 subterminal-centromeric chromosomes (Fig. 30) and belonged to Stebbins' 3A type. The karyotype was formulated as 2n = 2x = 6m + 6sm + 4st.

Ser. **Repentes** W. T. Wang

3.3.10 **R. sinovaginatus** W. T. Wang

This species is distributed in Yunnan, Sichuan, Guizhou, Gansu and Shaanxi. Three populations from Yunnan were examined and all found to be tetraploids with 2n = 4x = 32 (Figs. 26, 32 ~ 36). The chromosomes ranged from 5.3 ~ 3.5 μm in length, their mean length being 4.2 μm. Their karyotypes seemed to be more or less different from each other with respect to the chromosome morphology. The karyotype of the population from Baimangshan Mt., Deqen (Q. E. Yang 94-82), consisted of 10 median-centromeric, 10 submedian-centromeric and 12 subterminal chromosomes (2n = 4x = 10m + 10sm + 12st) (Fig. 32). There existed obvious heteromorphy between the first and the second chromosome pairs. The karyotype of the population from Yulongshan Mt., Lijiang (X. Gong 92-19) consisted of 10 median-centromeric, 4 submedian-centromeric, 14 subterminal-centromeric and 4 terminal-centromeric chromosomes (2n = 2x = 10m + 4sm + 14st + 4t) (Fig. 35). There existed obvious heteromorphy between the 11th and the 12th chromosome pairs. The karyotype of the population from Napahai, Zhongdian (X. Gong 92-31), consisted of 10 median-centromeric, 2 submedian-centromeric, 16 subterminal-centromeric and 4 terminal-centromeric chromosomes (2n = 4x = 10m + 2sm + 16st + 4t) (Fig. 36). There existed obvious heteromorphy between the second and the third chromosome pairs. The karyotypes of the three populations all belonged to Stebbins' 3A type.

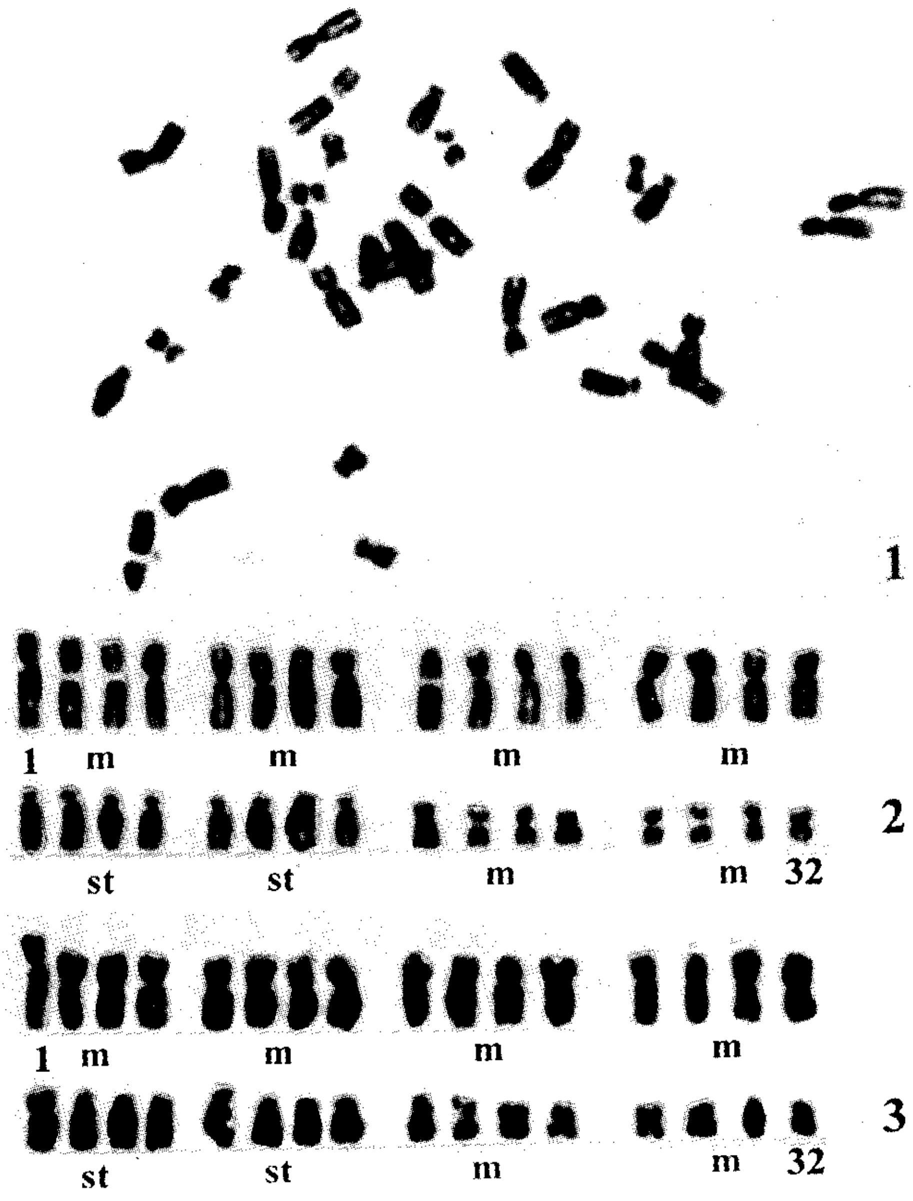
3.3.11 **R. chinensis** Bunge

This species is very widely distributed in China as well as in N Pakistan, NE India, Bhutan, Japan, Korea, Mongolia and Siberia of Russia. One population from Yunnan was examined and found to be diploid with 2n = 2x = 16 (Fig. 25, 31), confirming the count reported by Sha *et al.* (1995). The chromosomes ranged from 3.9 ~ 2.6 μm in length, their mean length being 3.5 μm. The karyotype consisted of 6 median-centromeric and 10 subterminal-centromeric chromosomes (Fig. 31) and belonged to Stebbins' 3A type. The karyotype was formulated as 2n = 6m + 10st.

3.4 **Halerpestes** E. Greene

3.4.1 **H. tricuspis** (Maxim.) Hand.-Mazz.

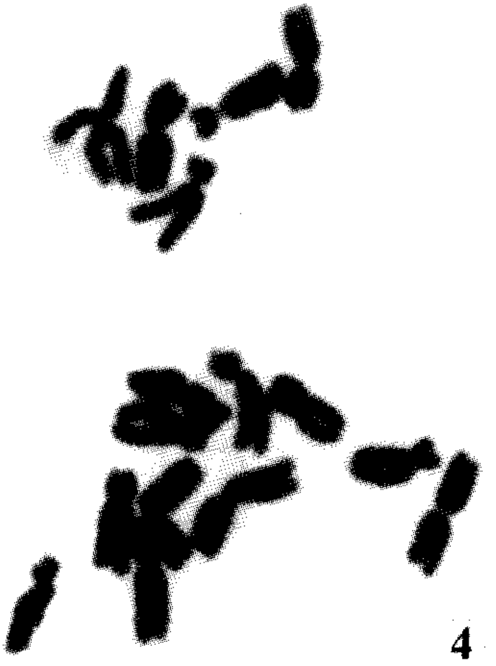
This species is distributed in China's Xizang, Qinghai, Gansu, S Ningxia, SE Xinjiang and Yunnan as well as in Nepal. One population from Qinghai was examined and found to be tetraploid with the chromosome number of 2n = 4x = 32 (Figs. 37, 39). The chromosomes ranged from 5.2 ~ 3.0 μm in length, their mean length being 4.1 μm. The karyotype consisted of 16 median-centromeric, 4 submedian-centromeric and 12 subterminal-centromeric chromosomes (Fig. 39) and belonged to Stebbins' 2A type. The karyotype was formulated as $2n = 4x = 16m + 4sm + 12st$.



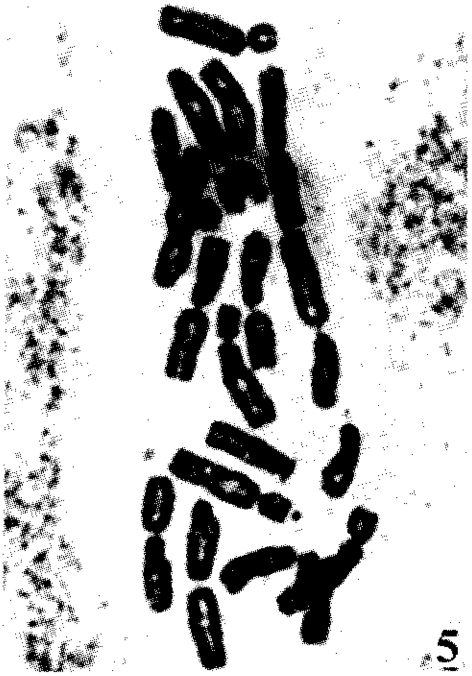
Figs. 1 ~ 3 Photomicrographs of chromosomes and karyograms of two populations in *Callianthemum pimpinelloides* (D. Don) Hook. f. et Thoms
1, 2. Population from Dali (Q. E. Yang 94-14); 3. Population from Zhongdian (X. Gong 9247). (all x 1940)

3.4.2 H. sarmentosa (Adams) Kom.

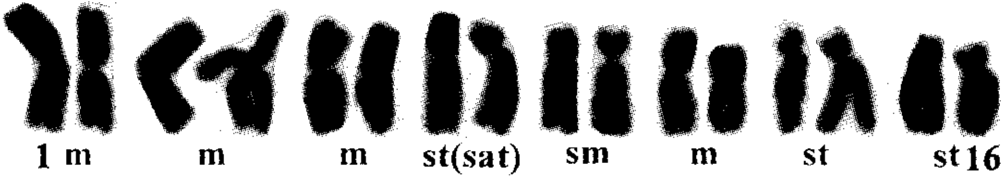
This species is distributed in China, Mongolia and Russia's Siberia. One population from Yunnan was examined and found to be tetraploid with the chromosome number of $2n = 4x = 32$ (Figs. 38, 40). The chromosomes ranged from 5.0 ~ 2.6 μm in length, their mean length being



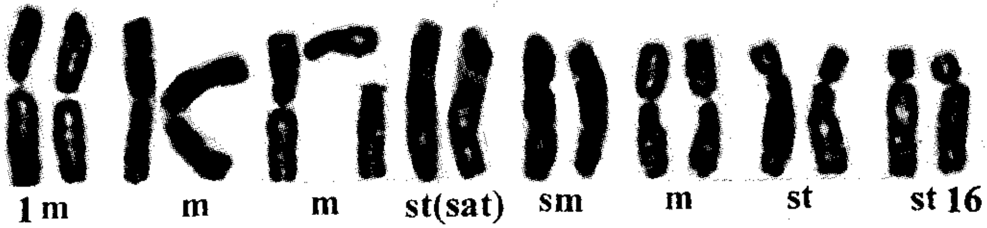
4



5



6



7

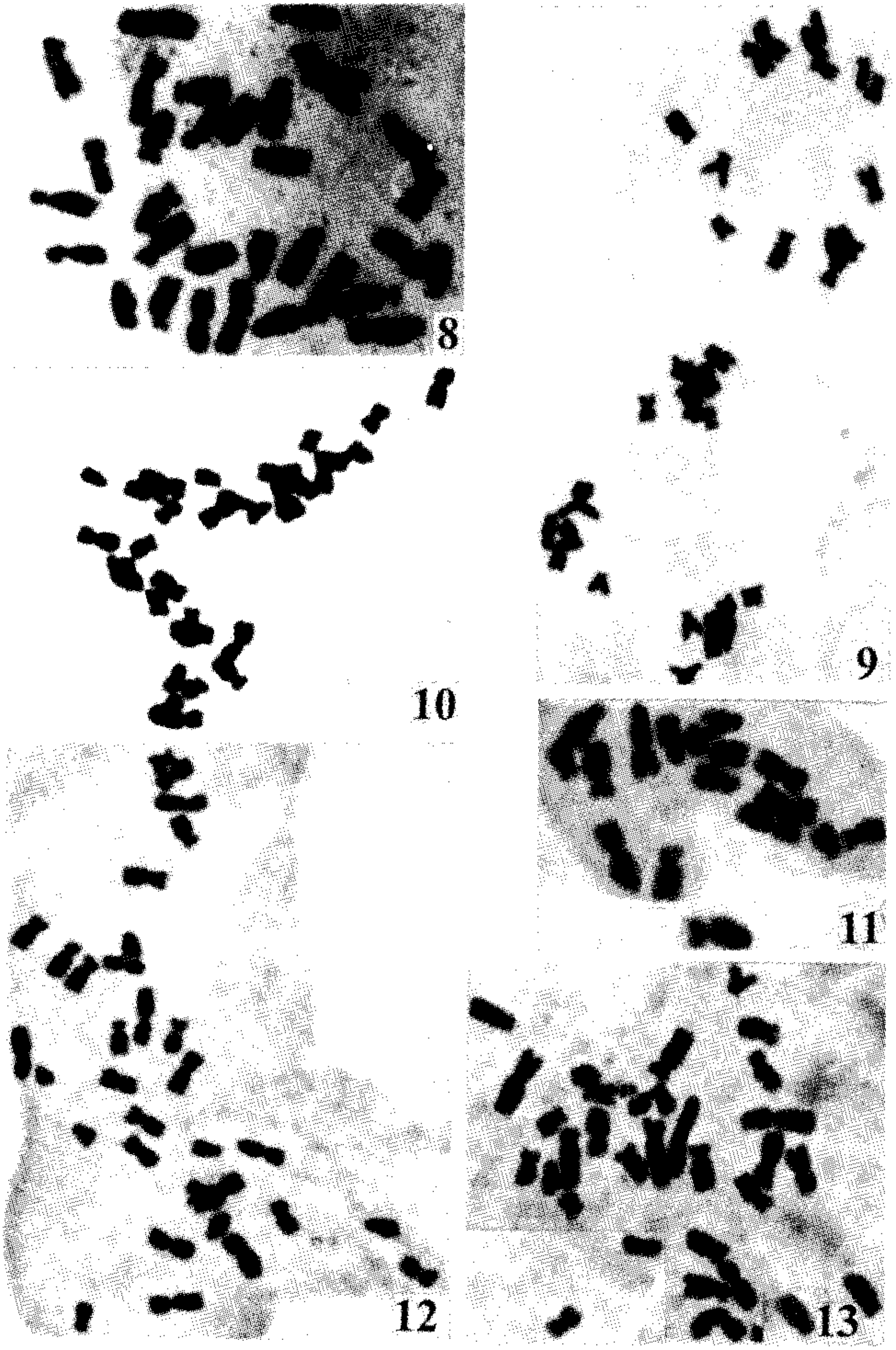
Figs. 4~7 Photomicrographs of chromosomes and karyograms of two populations in *Adonis brevistyla* Franch 4,6. Population from Lijiang (Q. E. Yang 94-130); 5,7. Population from Zhongdian (Q. E. Yang & H. Z. Kong 98-136). (all x 1940)

3.7 μm. The karyotype consisted of 16 median-centromeric, 4 submedian-centromeric and 12 subterminal-centromeric chromosomes (Fig. 40) and belonged to Stebbins' 2A type. The karyotype was formulated as $2n = 4x = 16m + 4sm + 12st$.

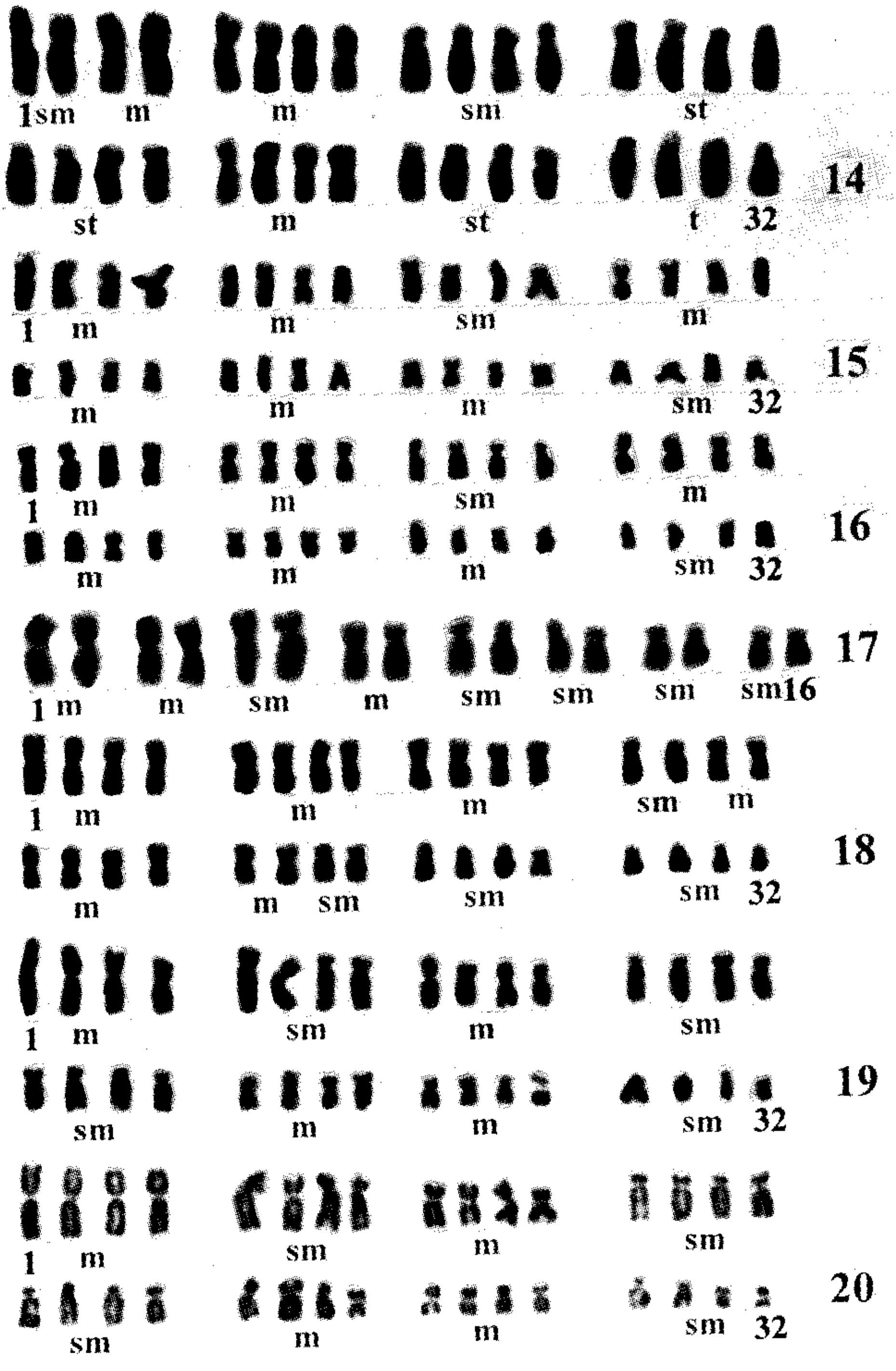
3.5 **Batrachium** S. F. Gray

3.5.1 **B. bungei** (Steud.) L. Liou

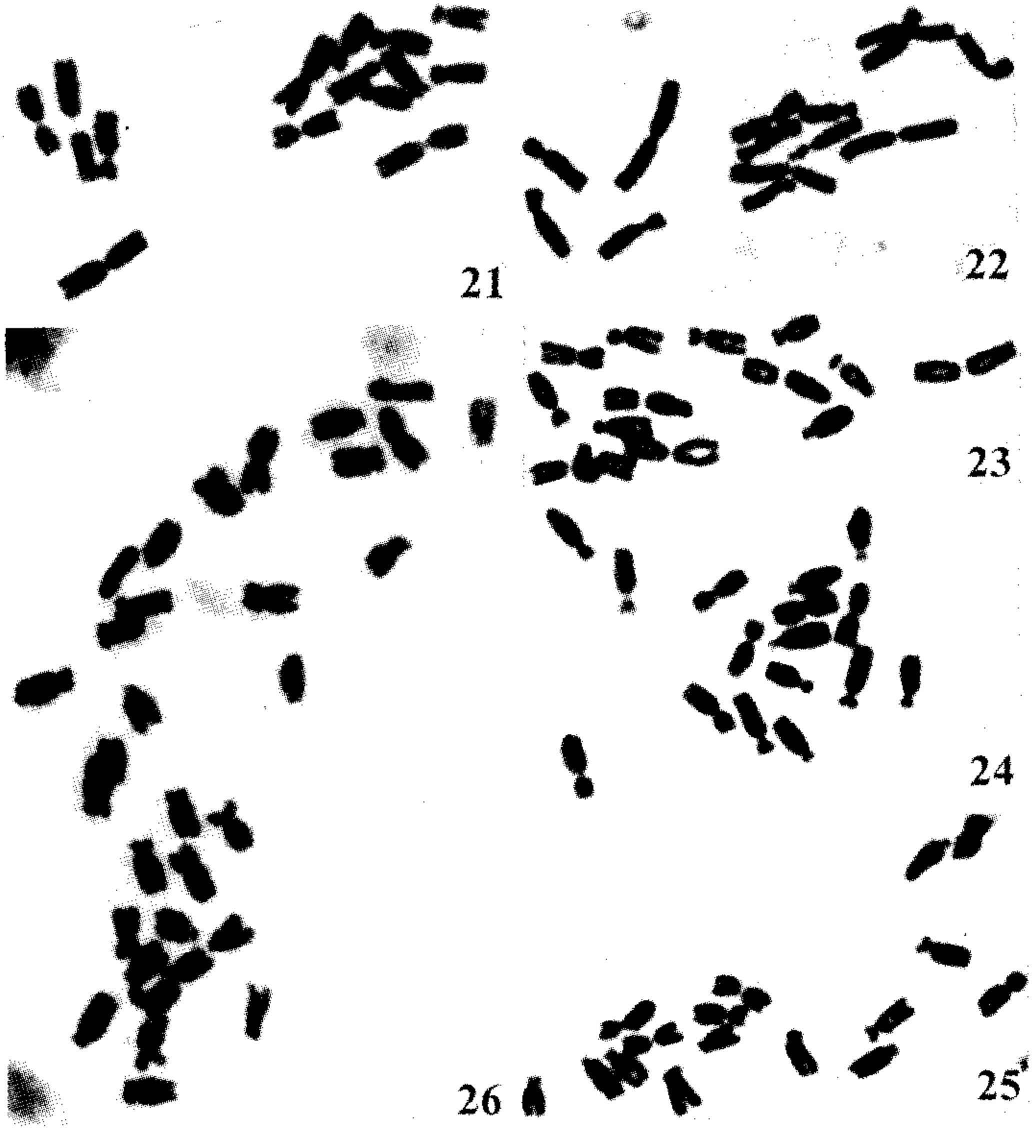
This species is distributed in N, E and SW China. One population from Yunnan was examined, in which two cytotypes were found, the diploid with $2n = 16$ (Figs. 41, 43) and the triploid



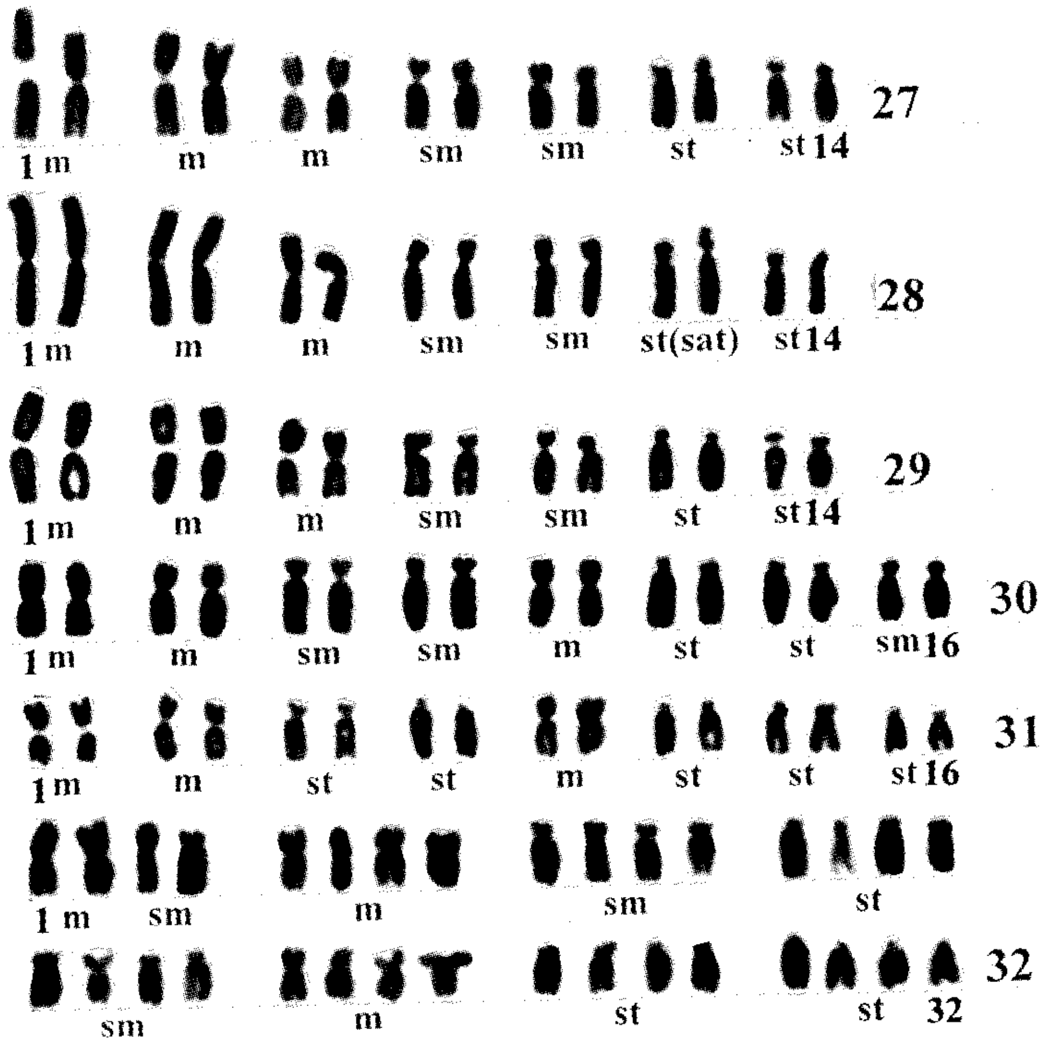
Figs. 8～13　Photomicrographs of chromosomes in six species of *Ranunculus*　8. *R. potaninii* Kom.; 9. *R. popovii* var. *stracheyanus* (Maxim.) W. T. Wang; 10. *R. tanguticus* (Maxim.) Ovcz.; 11. *R. nematolobus* Hand.-Mazz.; 12. *R. sceleratus* L.; 13: *R. ficariifolius* Lévl. et Vant. (all x 1940)



Figs. 14 ~ 20 Karyograms in six species of *Ranunculus* 14. *R. potaninii* Kom.; 15. *R. popovii* var. *stracheyanus* (Maxim.) W. T. Wang; 16. *R. tanguticus* (Maxim.) Ovcz.; 17. *R. nematolobus* Hand.-Mazz.; 18. *R. sceleratus* L.; 19. *R. ficariifolius* Lévl. et Vant. (population from Dali, Q. E. Yang 94-29); 20. *R. ficariifolius* Lévl. et Vant. (population from Weixi, Q. E. Yang & H. Z. Kong 98-203). (all x 1940)

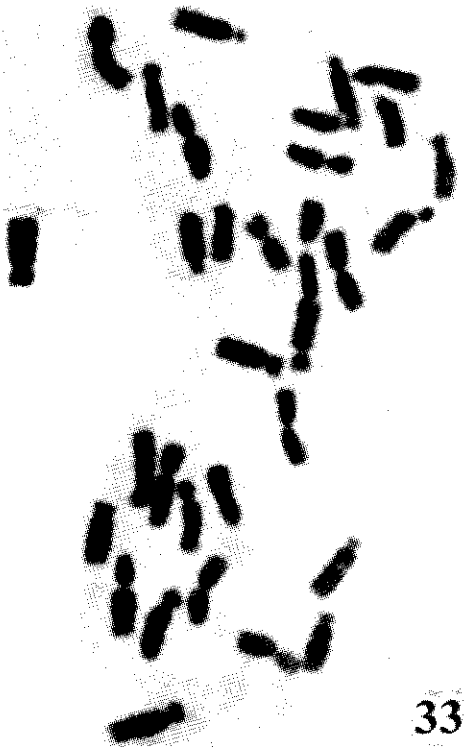


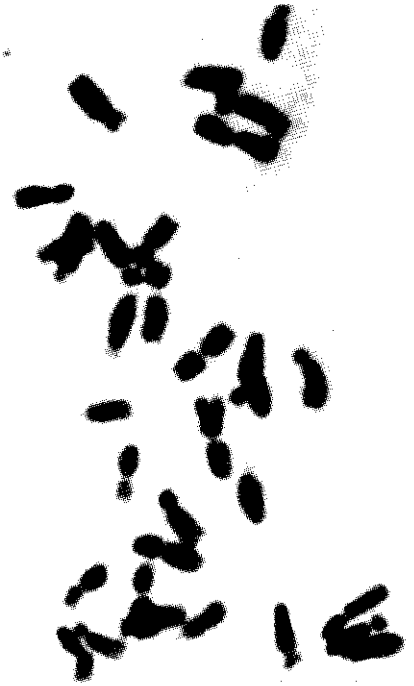
Figs. 21 ~ 26 Photomicrographs of chromosomes in five species of *Ranunculus* 21. *R*. *japonicus* Thunb. (population from Sichuan, Q. E. Yang 93-01); 22. *R*. *japonicus* Thunb. (population from Qinghai, Q. E. Yang 95-12); 23. *R*. *laetus* Wall.; 24. *R*. *trigonus* Hand.-Mazz.; 25. *R*. *chinensis* Bunge; 26. *R*. *sinovaginatus* W. T. Wang (population from Deqen, Yunnan, Q. E. Yang 94- 82). (all x 1940)

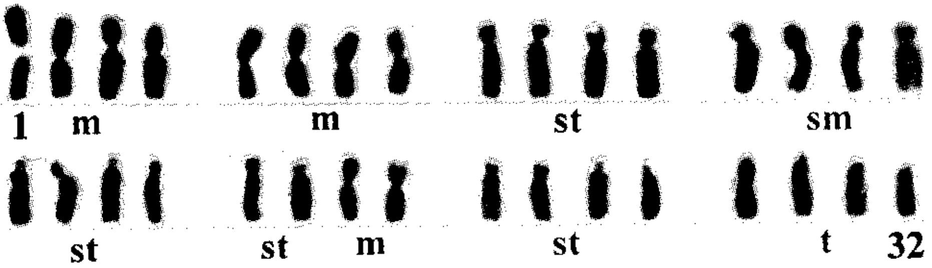


Figs. 27~32 Karyograms in five species of *Ranunculus* 27. *R. japonicus* Thunb. (population from Sichuan, Q. E. Yang 93-01); 28. *R. japonicus* Thunb. (population from Qinghai, Q. E. Yang 95-12); 29. *R. laetus* Wall.; 30. *R. trigonus* Hand.-Mazz.; 31. *R. chinensis* Bunge; 32. *R. sinovaginatus* W. T. Wang (population from Deqen, Yunnan, Q. E. Yang 94-82). (all x 1940)

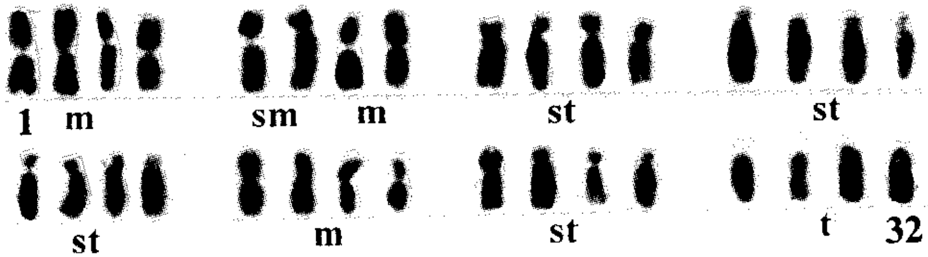
with 2n = 24(Figs. 42, 44). The diploid cytotype seemed to be commoner than the triploid one in the population but for a further clarification of the cytotype distribution within and between populations of this species, a detailed research using more exact sampling method must be carried out. The chromosomes ranged from 5.0~2.6 μm, their mean length being 3.7μm. The karyotype of the diploid cytotype consisted of 6 median-centromeric and 10 submedian-centromeric chromosomes (2n = 2x = 6m + 10sm) (Fig. 43) and belonged to Stebbins'2A type, and that of the triploid one consisted of 9 median-centromeric and 15 submedian-centromeric chromosomes (2n = 3x = 9m + 15sm) (Fig. 44). Although the seventh and eighth chromosome pairs in the diploid karyotype are described as sm, their arm ratio was fairly high, almost reaching 3.0.


33


34

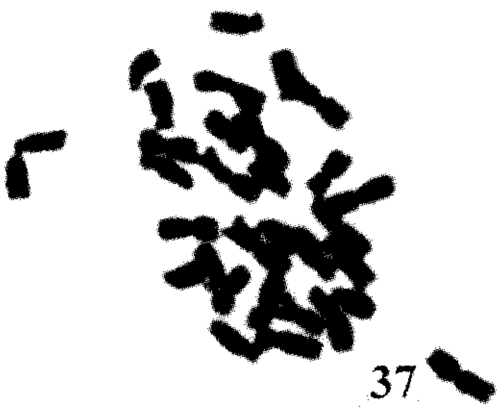


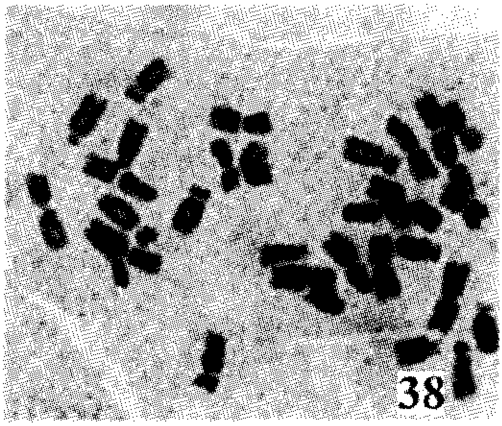
35

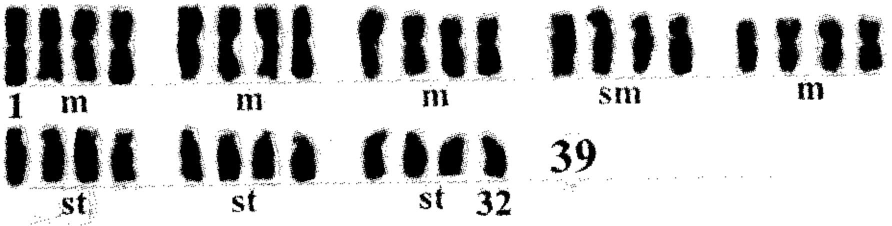


36

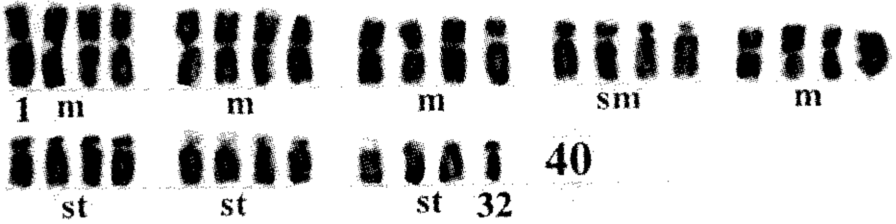
Figs. 33 ~ 36　Photomicrographs of chromosomes and karyograms of two populations in *R. sinovaginatus* W. T. Wang
33, 35. Population from Lijiang (X. Gong 92-19); 34, 36. Population from Zhongdian (X. Gong 92-31). (all x 1940)


37


38



39



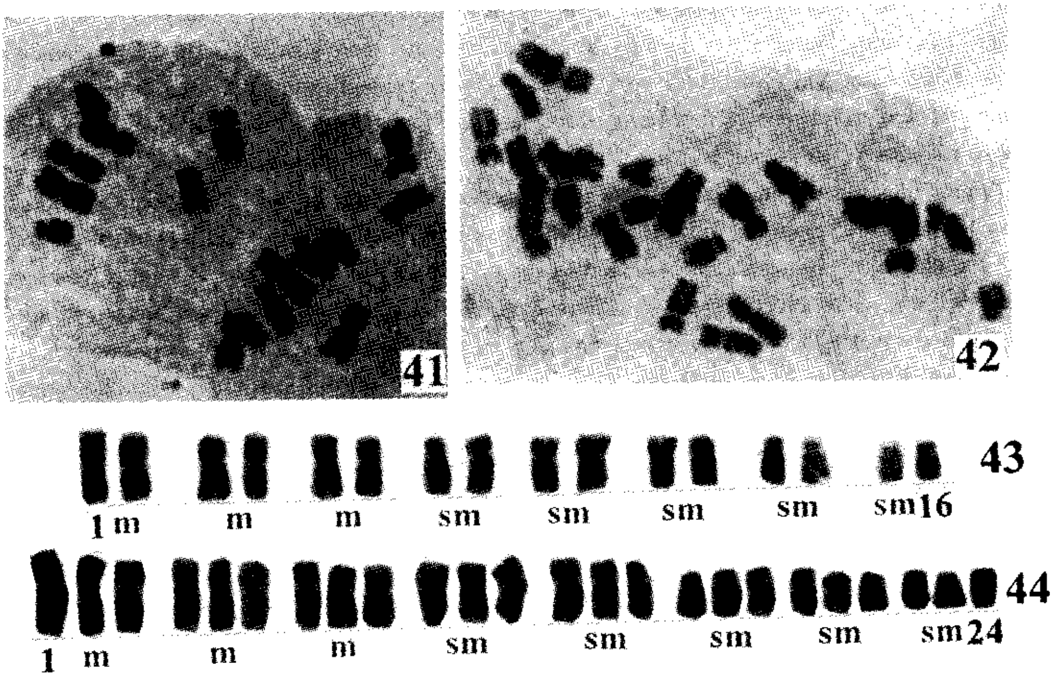
40

Figs. 37 ~ 40 Photomicrographs of chromosomes and karyograms in two species of *Halerpestes* 37, 39. *H. tricuspis* (Maxim.) Hand.-Mazz.; 38, 40. *H. sarmentosa* (Adams) Kom. (all x 1940)

4 Discussion

4.1 Among the eleven species of *Ranunculus* and five species of its four related genera studied, two species, *Ranunculus japonicus* and *R. laetus*, are diploids based on x = 7 (2n = 14), four species, *Adonis brevistyla*, *R. nematolobus*, *R. trigonus* and *R. chinensis*, are diploids based on x = 8 (2n = 16), nine species, *Callianthemum pimpinelloides*, *R. potaninii*, *R. popovii* var. *stracheyanus*, *R. tanguticus*, *R. sceleratus*, *R. ficariifolius*, *R. sinovaginatus*, *Halerpestes tricuspis* and *H. sarmentosa*, are tetraploids based on x = 8 (2n = 32), and one species, *Batrachium bungei*, has diploid and triploid cytotypes based on x = 8 (2n = 16, 24).

4.2 In karyotypic features, particularly in chromosome size and karyotypic symmetry, *Adonis brevistyla* seems to be well distinguished from the other species studied. Its chromosomes are obviously larger (10.8 ~ 7.9 μm) than those of the other species, and its karyotype is the most symmetric one among the species studied, belonging to Stebbins' 2A type. Tamura (1995) put *Adonis* and *Callianthemum* together into the tribe Adonideae of the subfamily Ranunculoideae and considered that they may be considerably isolated from other members of the Ranunculoideae. Tamura's viewpoints



Figs. 41 ~ 44 Photomicrographs of chromosomes and karyograms in *Batrachium bungei* (Steud.) L. Liou
41, 43. Diploid; 42, 44. Triploid. (all x 1940)

are partly supported by this study. My results show that cytologically *Adonis* can be indeed readily differentiated from *Ranunculus*, *Halerpestes* and *Batrachium*, three members in the tribe *Ranunculeae* DC., and also from *Callianthemum*, a genus which is usually considered to be closely related to *Adonis*. The chromosomes of *Callianthemum*, *Ranunculus*, *Halerpestes* and *Batrachium* are basically similar in size among the genera, though even within *Ranunculus* the chromosomes show a considerable variation in size among the species. The relatively large size of the chromosomes and the fairly symmetric karyotype in *Adonis* suggest that this genus should be a primitive member in the Ranunculoideae. In the Ranunculaceae, advanced species or genera seem to be characterized by asymmetric karyotypes (Levitsky, 1931) and/or small chromosomes (Kurita, 1958a) while primitive species or genera by symmetric karyotypes and/or large chromosomes.

4.3 Although the chromosomes of *Callianthemum*, *Ranunculus*, *Halerpestes* and *Batrachium* are similar in size, and the species here studied in *Ranunculus*, particularly in *Callianthemum*, *Halerpestes* and *Batrachium* are too few to allow making a detailed comparison of karyotypes of these genera, a glance at the karyograms of the five tetraploid species with very similar chromosome size, namely *C. pimpinelloides* (Figs. 2,3), *R. popovii* (Fig. 14), *R. sinovaginatus* (Figs. 32, 35, 36), *H. tricuspis* (Fig. 39) and *H. sarmentosa* (Fig. 40) clearly shows the intergeneric differences in the karyotypic composition of *Callianthemum*, *Ranunculus* and *Halerpestes*. The distinction of the genus *Batrachium* as a separate unit, however, does not receive support from the observations on the size and morphology of the chromosomes. *Batrachium* is often treated as a subgenus of *Ranunculus* (Diosdado, Pastor, Valdés, 1993; Dahlgren, 1991; Cook, 1966). Goepfert pointed out that the chromosomes of *Batrachium* are similar to those of *Ranunculus* sect. *Hecatonia* in size, and as such, Diosdado, Pastor and Valdés (1993) considered that there should exist some relationships between *Batrachium* and *Ranunculus* sect. *Hecatonia*. The present results have shown that in chromosome size and morphology *Batrachium bungei* appears to be more similar to other *Ranunculus* species, such as *R. nematolobus*, than to *R. sceleratus*, the only member of sect. *Hecatonia*. Indeed, from chromosomal data it seems that the subgeneric rank may be most appropriate for *Batrachium*, though its relationships with the members of subgen. *Ranunculus* should be further studied.

4.4 The eleven species of *Ranunculus* studied show a considerable variation in several chromosome characteristics such as chromosome size, karyotypic composition and karyotypic symmetry, so it seems apparent that a thorough revision of the Chinese *Ranunculus* might benefit from utilization of chromosomal data. Though the chromosomal data of the Chinese species are too limited to be conclusive for their natural grouping, a few conclusions can be made in connection with the present studies.

In Wang's classification of the Chinese *Ranunculus* (Wang, 1995a, 1995b), the four species, *R. potaninii*, *R. popovii* var. *stracheyanus*, *R. tanguticus* and *R. nematolobus*, all belong to ser. *Tangutici* Ovcz. of sect. *Auricomus* (Spach) Schur in subgen. *Ranunculus*, but the chromosomes of *R. potaninii* and *R. nematolobus* are obviously larger than those of *R. popovii* var. *stracheyanus* and *R. tanguticus*, so chromosomal data do not show that the former two species are closely related to the latter two.

Liou (1980) treated *R. nematolobus* as a variety of *R. tanguticus* (Maxim.) Ovcz., i.e. *R. tanguticus* var. *capillaceus* (Franch.) L. Liou, but Wang (1986) pointed out that *R. nematolobus* is markedly different from *R. tanguticus* in some gross-morphological characters, particularly in those of the receptacle and of the androecium and thus should be treated as an independent species. Wang's treatment is strongly supported by the present results. Cytologically, *R. nematolobus* is different from *R. tanguticus* not only in chromosome number ($2n=16$ vs. $2n=32$) but also in chromosome morphology and size. The present results do not also support Kadota's treatment of reducing *R. tanguticus* var. *capillaceus* (Franch.) L. Liou to *R. brotherusii* Freyn as a synonym. *R. brotherusii*, as reported by Kurosawa (1971), is a tetraploid with $2n=32$.

4.5 Kurita (1961) considered that in *Ranunculus* the chromosomes might evolve towards the decrease in their size. If this is a true representation of the evolutionary trend in chromosome size in the *Ranunculus*, then the species with small chromosomes, such as *R. popovii* var. *stracheyanus*, *R. tanguticus*, *R. ficariifolius* and *R. sceleratus*, might be relatively advanced. Their polyploid nature also indicates their advanced level in evolution.

4.6 *Halerpestes tricuspis*, a species mainly distributed in the Qinghai-Xizang Plateau, shows great variation in the foliar division and shape, based on which four varieties have been recognized (Wang, 1995c). Between this species and its two very close allies, *H. lancifolia* (Bert.) Hand.-Mazz. and *H. filisecta* L. Liou, there often exist intermediates. The three species may therefore constitute a taxonomic complex which is worthy of a further study (Wang, 1995c). The present results show that *H. tricuspis* is a tetraploid, indicating that this complex may be of a polyploid nature.

Acknowledgments I would like to express my sincere thanks to Mr. Fang Zhen-dong of Gesang Flower Co. Ltd., Zhongdian County, Yunnan, Mr. Gong Xun of Kunming Institute of Botany, the Chinese Academy of Sciences, and Drs. Luo Yi-bo and Kong Hong-zhi of Laboratory of Systematic and Evolutionary Botany, Institute of Botany, the Chinese Academy of Sciences, for their help in collecting living materials. I am grateful to Professor Gu Zhi-jian of Kunming Institute of Botany, the Chinese Academy of Sciences, for kindly leaving his research facilities at my disposal. My thanks also go to Professor Wang Wen-tsai for his help in identifying some specimens and Professor Hirosumi Fujishima of Tottori University, Japan, for his interest and invaluable discussion during the course of my research.

References

Cook C D K, 1966. A monographic study of *Ranunculus* subgenus *Batrachium* (DC.) A. Gray. Mitt Bot Staatssamml München, 6: 47 ~ 237

Coonen L P, 1939. The chromosomes of *Ranunculus*. Am J Bot, 26: 49 ~ 58

Dahlgren G, 1991. Karyological investigations in *Ranunculus* subg. *Batrachium* (Ranunculaceae) on the Aegean islands. Pl Syst Evol, 177: 193 ~ 211

Diosdado J C, Pastor J E, 1993. Karyological studies of some orophyte taxa of the genus *Ranunculus* L. from the Iberian Peninsula. Bot J Linn Soc, 111: 23 ~ 35

Diosdado J C, Pastor J E, Valdés B, 1993. Contributions to the karyological study of the genus *Ranunculus* L. subgenus *Batrachium* (DC.) A. Gray from the Iberian Peninsula. Bot J Linn Soc, 112: 75 ~ 87

D'Ovidio R, Marchi P, 1990. DNA content, karyotype structure analysis and karyotype symmetry in *Ranunculus* L. (Ranunculaceae). Italian species belonging to sections *Flammula* (Webb) Benson and *Micranthus* (Ovcz.) Nyarady. Caryologia, 43: 99 ~ 115

Fujishima H, 1986. Karyotype variations of *Ranunculus japonicus* Thunb. J Fac Educ Tottori Univ, Nat Sci, 35: 43 ~ 54

Fujishima H, 1990. Karyotype and variations of satellited chromosomes in *Ranunculus sceleratus* L. J Fac Educ Tottori Univ, Nat Sci, 39: 161 ~ 164

Fujishima H, 1991. Karyological studies on four species in the genus *Ranunculus* from Taiwan. La Kromosomo, Ⅱ-61: 2059 ~ 2067

Fujishima H, 1996. A karyomorphological study on *Ranunculus sceleratus* L. from the Korean Peninsula. J Fac Educ Tottori Univ, Nat Sci, 45: 121 ~ 123

Goepfert D, 1974. Karyotypes and DNA content in species of *Ranunculus* L. and related genera. Bot Notiser, 127: 464 ~ 489

Hara H, Kurosawa S, 1956. Cytotaxonomical notes on the *Ranunculus acris* group in Japan. Bot Mag (Tokyo), 69: 345 ~ 352

Kapoor B M, 1981. Karyomorphological studies in some species of *Ranunculus*. Фyton, 41: 153 ~ 164

Kapoor B M, Löve A, 1970. Chromosomes of Rocky Mountain *Ranunculus*. Caryologia, 23: 575 ~ 594

Kurita M, 1955. Cytological studies in Ranunculaceae Ⅰ. The karyotype analysis in the genus *Ranunculus*. Bot Mag (Tokyo), 68: 94 ~ 97

Kurita M, 1957. Chromosome studies in Ranunculaceae Ⅲ. Karyotypes of the subtribe Ranunculinae. Rep Biol Inst Ehime Univ, 2: 1 ~ 8

Kurita M, 1958a. Chromosome studies in Ranunculaceae Ⅷ. Karyotype and phylogeny. Rep Biol Inst Ehime Univ, 5: 1 ~ 14

Kurita M, 1958b. Chromosome studies in Ranunculaceae Ⅹ. Karyotypes and chromosome numbers of some genera. Rep Biol Inst Ehime Univ, 6: 9 ~ 16

Kurita M, 1960. Chromosome studies in Ranunculaceae ⅩⅦ. Karyotypes of some species. Mem Ehime Univ, Sect Ⅱ (Sci), Ser B (Biol), 4: 59 ~ 66

Kurita M, 1961. Chromosome studies in Ranunculaceae ⅩⅠⅩ. Chromosome size in *Ranunculus* species in the eight-chromosome series. Mem Ehime Univ, Sect Ⅱ (Sci), Ser B (Biol), 4: 263 ~ 268

Kurosawa S, 1971. Cytological studies on some eastern Himalayan plants and their related species. Univ Mus Univ Tokyo, Bull, 2: 355 ~ 364

Levan A, Fredga K, Sandberg A A, 1964. Nomenclature for centromeric position on chromosomes. Hereditas, 52: 201 ~ 220

Levitsky G A, 1931. The karyotype in systematics. Bull Appl Bot Genet Pl Breed, 27: 187 ~ 239

Liao L, Chen Y, 1991. Karyotype variation of *Ranunculus japonicus* from Jiangxi. Acta Phytotax Sin, 29: 184 ~ 186

Liao L, Xu L L, 1997. New taxa of the genus *Ranunculus* from China and their karyotypes. Acta Phytotax Sin, 35: 57 ~ 62

Liao L, Xu L L, Fang L, 1996. Study on the karyotypes of two species and one variety in *Ranunculus* from China. Acta Bot Yunnan, 18: 331 ~ 335

Liao L, Xu L L, Yang D Q, 1991. Studies on karyotypes of 5 species in *Ranunculus* from Jiangxi. Acta Phytotax Sin, 29: 178 ~ 183

Liou L, 1980. *Ranunculus* L. In: Flora Reipublicae Popularis Sinicae. Beijing: Science Press. 28: 255 ~ 331

Roy S H, Sharma A K, 1971. Cytotaxonomic studies on Indian Ranunculaceae. Nucleus, 14: 132 ~ 143

Sha W, Wang L H, Yang X J *et al.*, 1995. Chromosome numbers of 20 species from northeast China. J Wuhan Bot Res, 13: 180 ~ 182

Stebbins G L, 1971. Chromosomal Evolution in Higher Plants. London: Edward Arnold (Publishers) Ltd

Suda Y, Herai T, 1991. Differentiation of *Adonis* L. in Japan Ⅰ. Somatic chromosome number and chromosome morphology. Sci Rep Tohoku Univ, 4th ser (Biol), 40: 47 ~ 73

Tamura M, 1995. Ranunculaceae. In: Hiepko P ed. Die Natürlichen Pflanzenfamilien. Zwei Aufl, 17a(4). Berlin: Duncker and Humblot

Vir Jee D C, Kachroo P, 1985. Chromosomal conspectus of some alpine-subalpine taxa of Kashmir Himalaya. Chromosome Inform Serv, 39: 33 ~ 35

Wang W T, 1986. Notulae de Ranunculaceis Sinensibus (ⅠⅩ). Bull Bot Res, 6: 1 ~ 42

Wang W T, 1995a. A revision of the genus *Ranunculus* in China (Ⅰ). Bull Bot Res, 15: 137 ~ 180

Wang W T, 1995b. A revision of the genus *Ranunculus* in China (Ⅱ). Bull Bot Res, 15: 275 ~ 529

Wang W T, 1995c. Notulae de Ranunculaceis Sinensibus (ⅩⅧ). Guihaia, 15: 97 ~ 105

Yang Y P, Wu S G, 1993. Chromosomal reports on some plants of Hohxil region, Qinghai(1). Acta Bot Yunnan, 15: 173 ~ 178

Yang Q E, Luo Y B, Hong D Y, 1994. A karyotypic study of six species in the Ranunculaceae from Hunan, C China. Guihaia, 14: 27 ~ 30

Yang Q E, 2000. *Ranunculus wangianus* Q. E. Yang, a new species from NW Yunnan, China and its karyotype. Acta Phytotax Sin, 38: 551 ~ 556

摘要 研究了国产毛茛属 *Ranunculus* L. 11种及其4个近缘属——美花草属 *Callianthemum* C. A. Meyer、侧金盏花属 *Adonis* L.、碱毛茛属 *Halerpestes* E. Greene、水毛茛属 *Batrachium* S. F. Gray 5种植物的染色体数目和形态。发现美花草 *C. pimpinelloides* (D. Don) Hook. f. et Thoms.、川滇毛茛 *R. potaninii* Kom.、深齿毛茛 *R. popovii* var. *stracheyanus* (Maxim.) W. T. Wang、高原毛茛 *R. tanguticus* (Maxim.) Ovcz.、石龙芮 *R. sceleratus* L.、西南毛茛 *R. ficariifolius* Lévl. et Vant.、褐鞘毛茛 *R. sinovaginatus* W. T. Wang、三裂碱毛茛 *H. tricuspis* (Maxim.) Hand.-Mazz.和碱毛茛 *H. sarmentosa* (Adams) Kom. 9种植物为染色体基数 x = 8 的四倍体 (2n = 4x = 32)；短柱侧金盏花 *A. brevistyla* Franch.、丝叶毛茛 *R. nematolobus* Hand.-Mazz.、棱喙毛茛 *R. trigonus* Hand.-Mazz.、茴茴蒜 *R. chinensis* Bunge 4种植物为染色体基数 x = 8 的二倍体(2n = 2x = 16)；毛茛 *R. japonicus* Thunb.、黄毛茛 *R. laetus* Wall. 2种植物为染色体基数 x = 7 的二倍体(2n = 2x = 14)；水毛茛 *B. bungei* (Steud.) L. Liou 有二倍体(2n = 2x = 16)和三倍体(2n = 3x = 24)两种细胞型。根据染色体资料，讨论了上述5属的属间关系和毛茛属中一些种的种间关系。

关键词 毛茛科；毛茛属；美花草属；侧金盏花属；碱毛茛属；水毛茛属；染色体数目；核型

（责任编辑 白羽红）